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File E182866
Project 01NK17676

September 17, 2001

REPORT

on

STATIC INVERTERS AND CONVERTERS
FOR USE IN INDEPENDENT POWER SYSTEMS

* *

Complementary Product Category
POWER CONVERTERS/INVERTERS AND POWER
CONVERTER/INVERTER SYSTEMS

Advanced Energy Systems, Inc.
Wilton, NH

DESCRIPTION

PRODUCT COVERED:

USR, CNR Utility Interactive or MultiMode, Power Conversion System, Model PP10.

USR indicates investigation to UL 1741, Static Inverters and Converters for Use in Independent Power Systems.

CNR indicates investigation to CAN/CSA-C22.2 No. 107.1 Commercial and Industrial Power Supplies, including the Amendment for Photovoltaic Equipment.

ELECTRICAL RATING:

	Input DC			Output AC				
Model	V	Voc	A	V ac	A	W	Hz	PF
PP10	42-90	90	200	120/240	30/60	6500	59.3-60.5	1

	PP10
Max utility backfeed current (AC)	60 A
Max output fault current (AC)	60 A
Max branch circuit overcurrent protection (A)	60 A
Max Array Short Circuit Current (DC)	200 A
For use in a maximum, air ambient of	40°C

CONDITIONS OF ACCEPTABILITY (NOT FOR FIELD REPRESENTATIVE'S USE):

Special Considerations - The following items are considerations that were made in the evaluation of this product.

The steel enclosure is electrically grounded to the unit circuitry.

The equipment is intended to be installed within a suitable enclosure for the end product and operating environment.

The need for external equipment disconnect devices shall be evaluated in the end product.

This product must be installed on a dedicated Branch circuit with a Listed Breaker rated maximum 60A.

This product has been judged on the basis of the required spacings in the First Edition of the Standard for Static Inverters and Charge Controllers for use in Photovoltaic Power Systems, UL 1741.

This unit must be used with a neutral conductor when exporting power in Utility Interactive Mode.

MARKINGS:

Each product shall be marked on R/C (PGDQ2) Marking Labeling System suitable for the material involved with the following in addition to information detailed in the Sec. Gen.

A unit shall be plainly and permanently marked where it will be readily visible, after installation, with:

a) The manufacturer's name, trademark, or other descriptive marking by which the organization responsible for the product may be identified - hereinafter referred to as the manufacturer's name.

b) A distinctive catalog number or the equivalent.

c) The day or other dating period of manufacture not exceeding any three consecutive months. The repetition time cycle of a date code shall not be less than 20 years. The date code shall not require reference to the manufacturer's records to determine when the power conditioning unit was manufactured.

Exception No. 1: The manufacturer's identification may be in a traceable code when the unit is identified by the brand or trademark of a private labeler.

Exception No. 2: The date of manufacture may be abbreviated in a nationally accepted conventional code, or in a code affirmed by the manufacturer.

This inverter is intended to be connected only to a dedicated branch circuit.

CONSTRUCTION DETAILS:

Unless otherwise described in individual Reports, the following paragraphs apply to all equipment included in this Procedure.

Corrosion Protection - Ferrous metal parts protected by painting, plating or equivalent.

Earthing/Bonding - Accessible dead-metal parts liable to become energized by hazardous voltage circuits, including fan guards, screens and cover plates, reliably connected by bolts, straps or wires to power supply circuit earthing means. Metal-to-metal contact provided by welding, machine bolts, nuts and lock washers and/or paint piercing washers.

Insulating Tubing - (YDPU2), rated minimum 105°C, 300 V.

Internal Plastic Part Materials -(QMFZ2) flammability rating minimum 94V-2.

Exception: Specific items noted in the descriptive sections of this Procedure. Small parts (i.e., gears, cams, belts, bearings, etc.) which would contribute negligible fuel to a fire, are exempt from flammability requirements if separated from electrical parts capable of raising the temperature of the plastic to its ignition point under fault conditions 1) by at least 13 mm of air or 2) by a solid barrier of material 94V-1 or better. No separation from insulated wires and cables is required.

Internal Wiring - Routed away from sharp edges. DC wiring: Listed building wire or (AVLV2): FEP, PTFE, PVC, TFE, neoprene or surface marked VW-1; rated minimum 105°C, 300 V. Routed away from AC primary uninsulated live parts. AC Primary: Listed building wire or (AVLV2), rated minimum 105°C, 300 V, FEP, PTFE, PVC, TFE, neoprene, or surface marked VW-1; routed away from DC wiring uninsulated live parts, and unless insulated for the highest voltage involved, from insulated AC primary circuit wiring.

Mechanical Assembly - Enclosure parts and component mounting assemblies reliably secured by welding, thread forming screws, rivets or machine bolts with nuts and lock washers or star washers or any combination thereof.

Metallized Coatings - Not permitted on inside surfaces of thermoplastic enclosures unless specifically described in Report.

PWB's - (ZPMV2), flammability rating minimum 94V-1, minimum 1 oz copper cladding, operating temperature rating minimum 105°C unless otherwise specified in individual descriptive sections.

Exception: The power PWB's have 4 oz. Copper

Soldered Connections - Mechanically secured before soldering.

Wire Positioning Devices - (ZODZ2), rated minimum 105°C. Stud mounted or adhesive backed types suitable for application to surface involved.

Wiring Terminations - Listed or (ZMVV2); or Listed or (RFWV2), suitable for the number and AWG of wires. Assembled in accordance with manufacturer's specifications.

MODEL PP10 - FIG. 1 (N02-00263) and FIG. 2 (N02-00264)

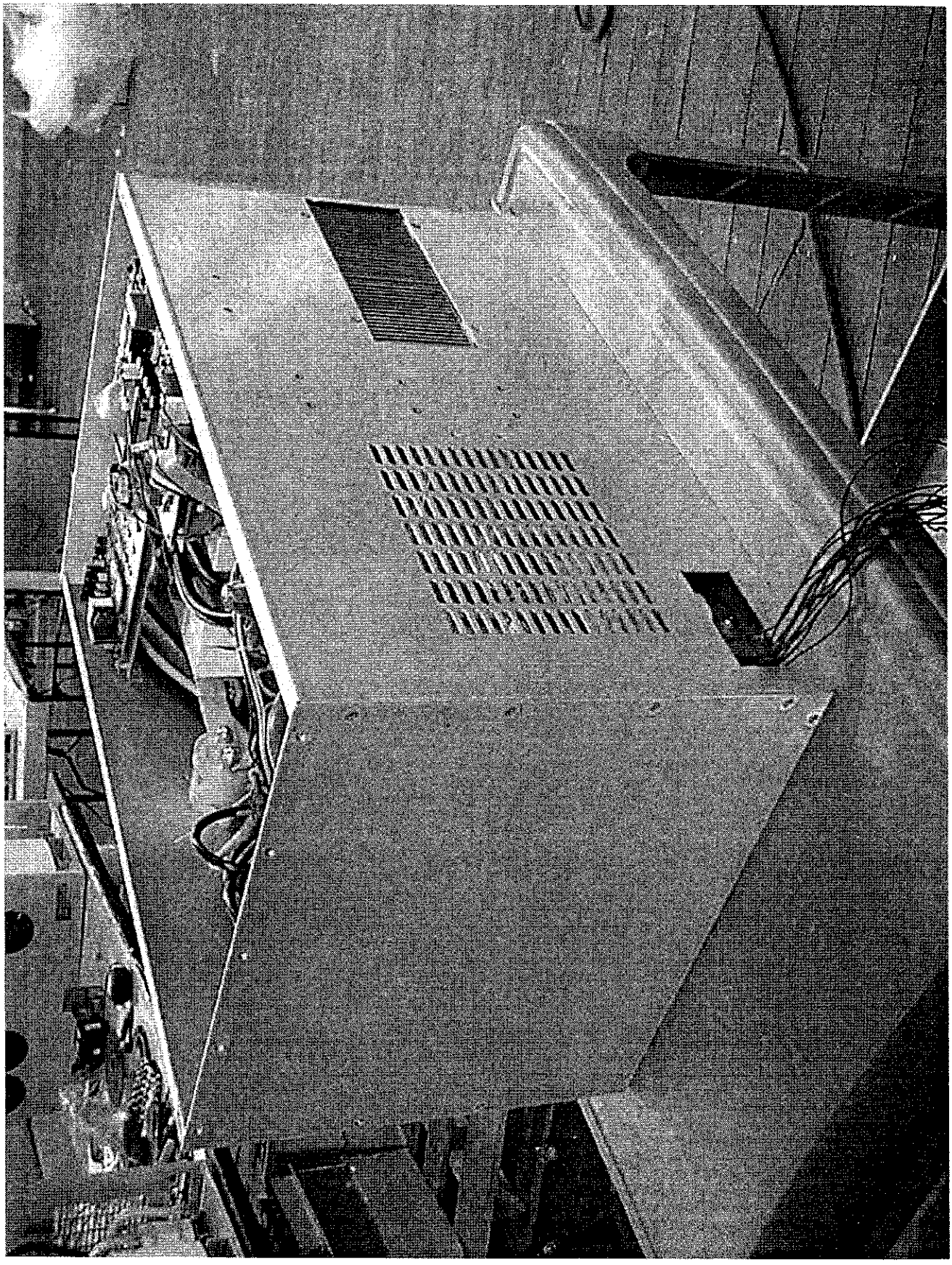
1. Enclosure - Shaped as shown, consists of the following parts, Base, Front Panel, and Side Panels.

   A. Base - Constructed from Aluminum with overall dimensions of 45.7 by 66.8 cm and 3.35 mm thick.

   B. Front Panel - Constructed from Aluminum with overall dimensions of 45.7 by 38 cm, with minimum thickness of 3.12 mm. Includes cutouts for base mounting extensions, supply wires, and communication connectors.

   C. Side Panels - Total of two provided, each is constructed from Aluminum. The two panels are 66.8 by 38 cm, and a minimum of 2 mm thick. The left side panel is provided with 41 ventilation openings, elliptical in shape, measuring 6.2 by 25 mm. In addition, a cut out measuring 25.4 by 11.8 cm is provided for the heat sink. The right side panel is provided with three openings for the fans. Openings are circular in shape with a 11.5 cm diameter. Two of the openings are located on the opposite side as the heat sink, with the third opening provided next to the transformer.

2. Thermostat - R/C(XAPX2) Two provided, Bi-Metal thermostat, rated 95°C, located under control board. One mounted to the top of heat sink near air output. Second mounted on internal cross bar of unit.



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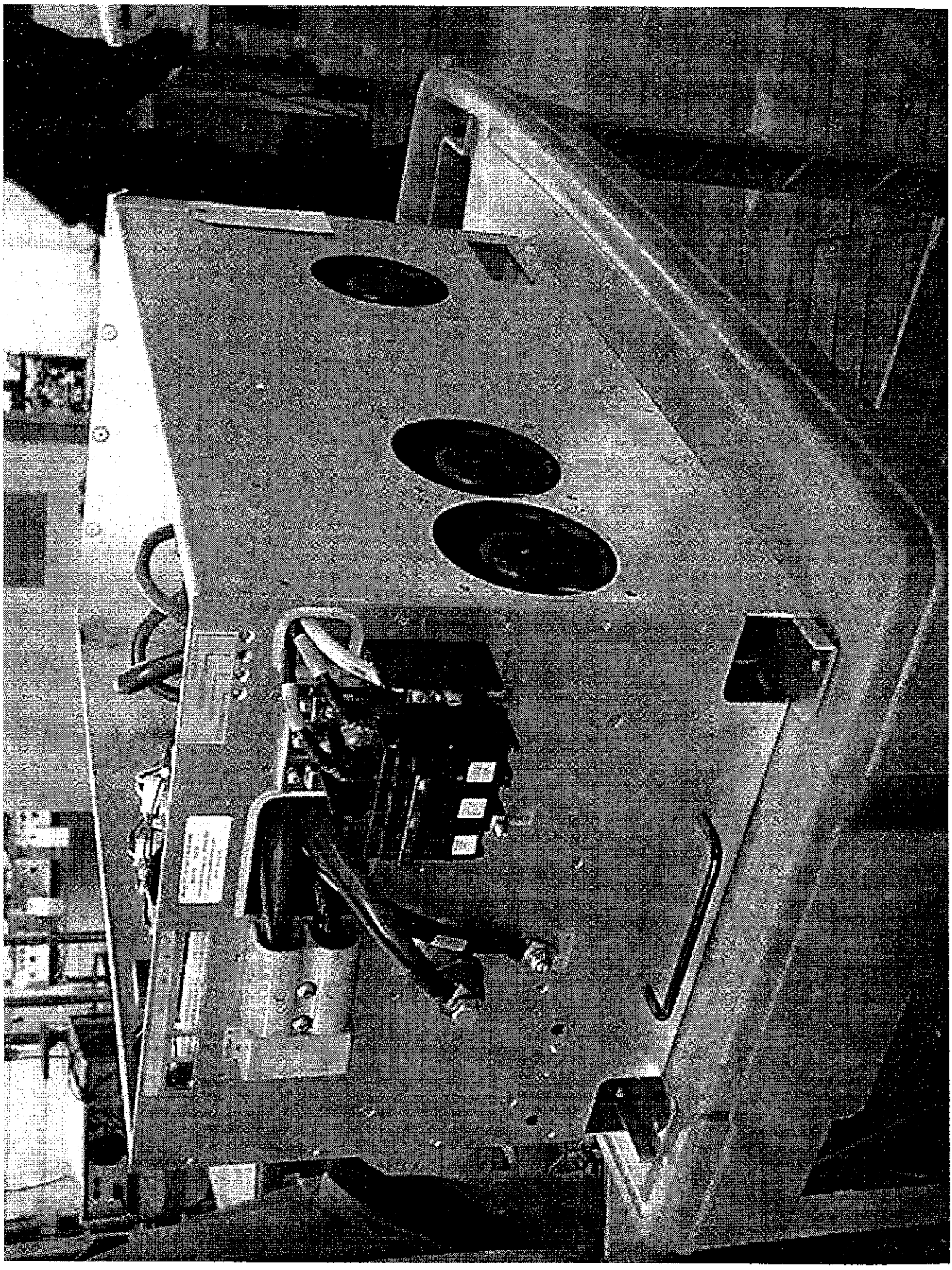

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WIRING COMPARTMENT INTERNAL - FIG. 3 (NO2-00267)

1. AC Circuit Breakers - One provided, Listed (DIVQ), Siemens Part No. BQ2B1001, rated 120 V ac, 100 A minimum, provided with three Listed (ZMVV) connectors. Support/Separators for connectors, R/C (QMFZ2) rated 90°C minimum.

2. DC Fuse - Listed (DIVQ), four provided, three rated 125 V dc, 50 A, trip 62.5 A, the other one is rated 125 V dc, 5 A. Provided with three Listed (ZMVV) connectors. Support/Separators for connectors, R/C (QMFZ2) minimum rating of 90°C.

3. AC Contactor - Two provided, R/C (QPQQ), 3 pole Siemens Sirius 3RT1023-1B, rated 120 V ac, FLA 25, LRA 150.

4. DC Contactor - One provided, R/C (YCFT2) Kilovac model EV200A rated 320 V dc, 200 A.

5. Power Distribution Blocks - Three provided, Listed (QPQS) rated 175 A minimum.

6. Surge Diodes - Five provided, R/C (XUHT2) Sussex, Type AX4-200. Each is located as follows: two from the Load AC Circuit Breaker to ground, one from AC neutral to ground, one from PV Positive to ground, one from PV Neutral to ground

7. Current Sensors - Two provided located near transformer, one near communication board, CR-Magnetics, Type 172000T, all wiring passing through the sensors must be covered with sleeving/tubing R/C(YDPU2), R/C (YDRY2) or R/C (YDTU2) rated a minimum 300 V ac, 105°C.

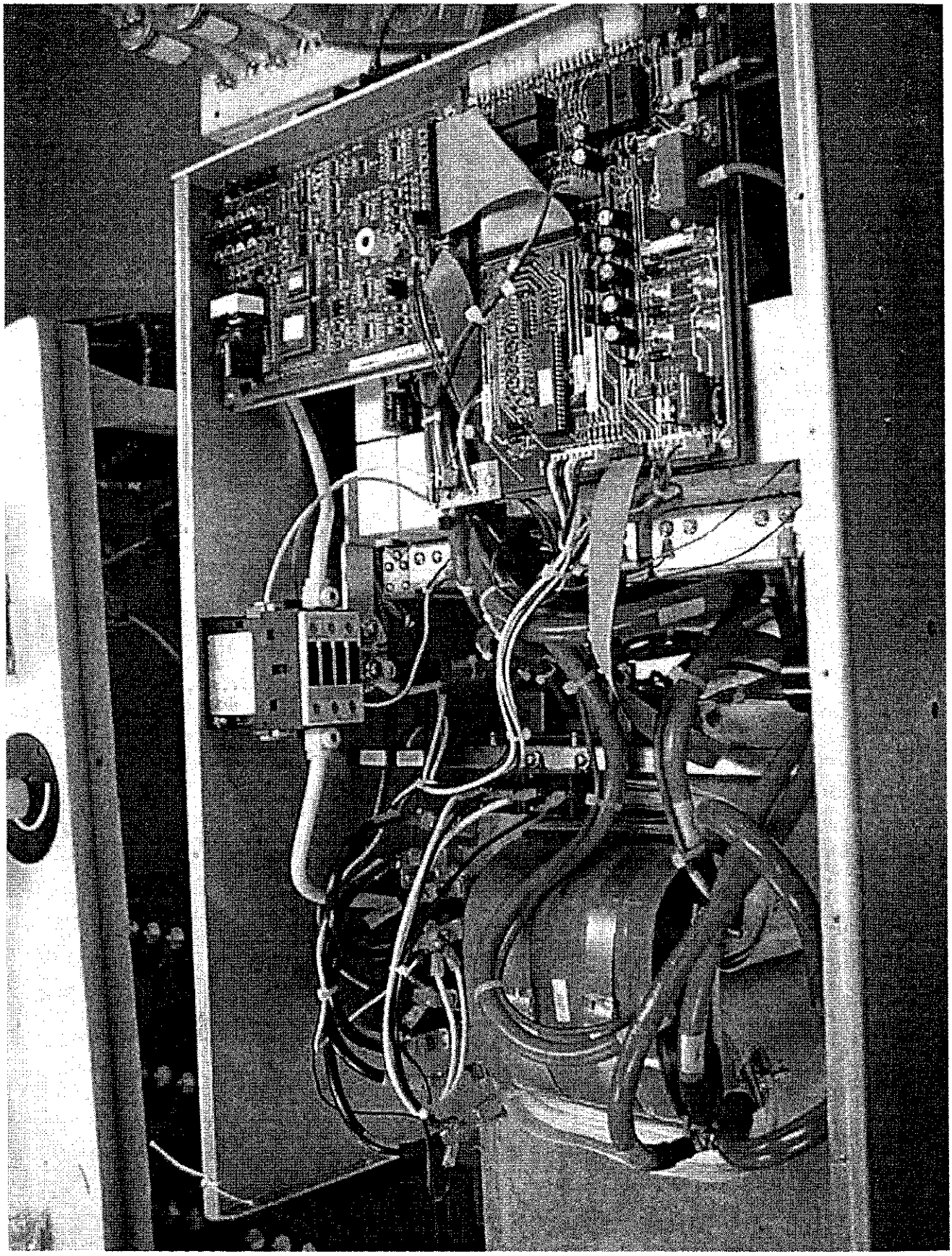
8. DC Current Sensor - Five provided, LEM Model LA100P, rated 200 A, 2000:1, located as follows: One in FC in, one in DC-DC out, one in battery, one in inverter primary, one in inverter input.

9. Internal Wiring - Listed or R/C (AVLV or AVLV2) rated 105°C. Any of the DC input wiring or any internal wiring that may come in contact with the DC input wiring or DC bus bars must be rated 600 V or double sleeved for a total of 600 V.

10. Resistors (R1, R2) - 2.0k ohms, 3 W, located on I/O board.

11. Resistors (R4-R9) - 1.0M ohms, 2 W, located on I/O board.

12. Relays - Four provided, R/C (NKCR2) located on I/O board. Output contacts are rated minimum of 240 V ac and 15 A.



N02-00267

TRANSFORMER COMPARTMENT - FIG. 4 (N02-00268)
AND FIG. 5 (N02-00266)

1. Transformer - R/C (XPTQ2) Honeywell Inc. Model T600702, 26 to 120/240 V, 7 kVA, 60 Hz. Constructed as noted below. All transformer input and output wires are cable tied in a manner to prevent rotation and loosening.

2. Inverter Inductor - Regional Mfg. Specialist, Part No. L2000203, 30 uH, constructed as follows

   A. Core - Part No. AMCC400, 2.7 in. by 3.1 in. by 0.87 in.

   B. Windings - Two provided, each consists of 9 turns of No. 4 square magnet wire.

   C. Windings to Core Insulation - R/C (QMFZ2) Nomex 410, rated 105°C minimum, one layer 0.007 in. thick, and two layers each 0.010 thick.

   D. Outer Wrap - R/C (QMFZ2) Nomex 410, rated minimum 105°C minimum, two layers, each layer is 0.007 in thick.

   E. Varnish - R/C (QMFZ2) Dolph, Part No. BC-346-A, rated 180°C.

   F. Edge Margins - Minimum 0.157 in.

   G. Shrink Tubing - R/C (YDPU2) rated 300 V ac minimum, 105°C, VW-1, applied to outside turns.

3. Charger Inductor - Regional Mfg. Specialist, Part No. L200201, 225 A, 30 +/- 3μH, constructed as follows:

   A. Core - Part No. AMCC-63, 2.1 in. by 1.2 in. by 0.625 in.

   B. Two provided, each consists of five turns of 4 x 65 A Litz wire.

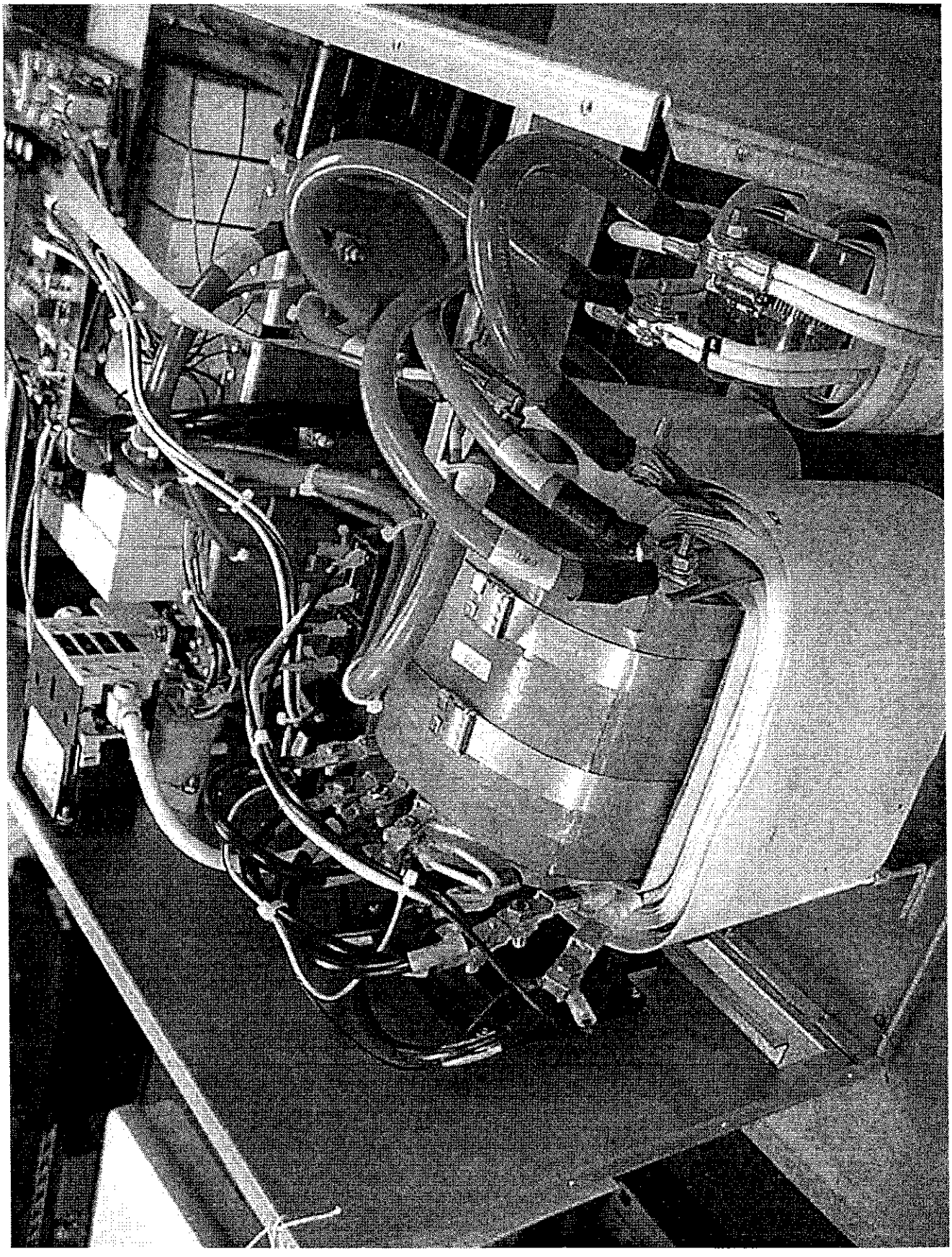
   C. Windings to Core Insulation - R/C (QMFZ2) Nomex 410, rated 105°C minimum, one layer 0.007 in. thick and two layers, each is 0.010 in. thick.

   D. Outer Wrap - R/C (QMFZ2) Nomex 410, rated 105°C minimum, two layers, each is 0.007 in thick.

   E. Varnish - R/C (QMFZ2) Dolph, Part No. BC-346-A, rated 180°C.

   F. Edge Margins - Minimum 0.157 in.

   G. Shrink Tubing - R/C (YDPU2) rated a minimum 300 V ac, 105°C, VW-1, applied to outside turns.



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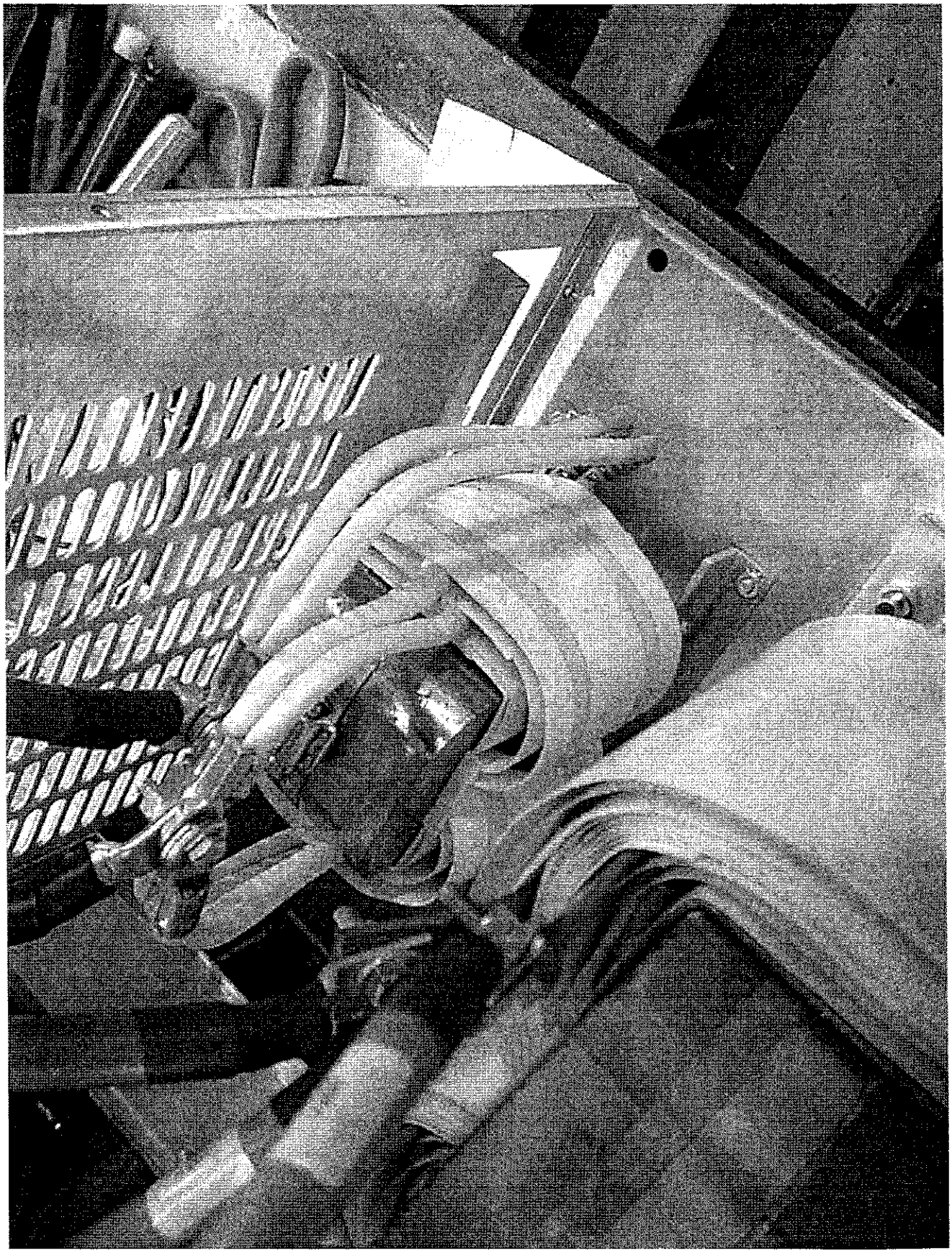


N02-00266

4. Front Panel Standoff - R/C (QMFZ2) Rittal, Part No. SW36, rated 135°C.

5. Heat Sink - Extruded aluminum, base plate is 25.4 by 11.8 cm. Fins, total of 41, each is 4.5 in by 6.0, by 0.125 in thick. Fins are secured to base plate R/C (QMFZ2) epoxy, Cast-Coat Inc., Type CC3-301AD-FR.

6. Fan - three provided, each is R/C (GPWV2) Matsushita Electric, Model FBA12G12U, rate 12.0 V dc, 0.65 Amps.

7. Capacitor - Evox/Rifa, electrolytic, Type UPE, rated 2700 uF, 420 V dc.

8. Internal Wiring - Listed or R/C (AVLV or AVLV2) rated 105°C. Any of the DC input wiring or any internal wiring that may come in contact with the DC input wiring must be rated 600 V or double sleeved for a total of 600 V.

CHARGER/INVERTER PCB - FIG. 6 (N02-00265)

General - There are two of these charger/input printed circuit boards.

1. Power Switching Semi-Conductors - Three provided, R/C (QQQX2) SemiKron Inc. Two are Type SkiiP87MB010D used in the Inverter Bridge circuit and one is Type SKiiP87MAR016D used in the Charger circuit.

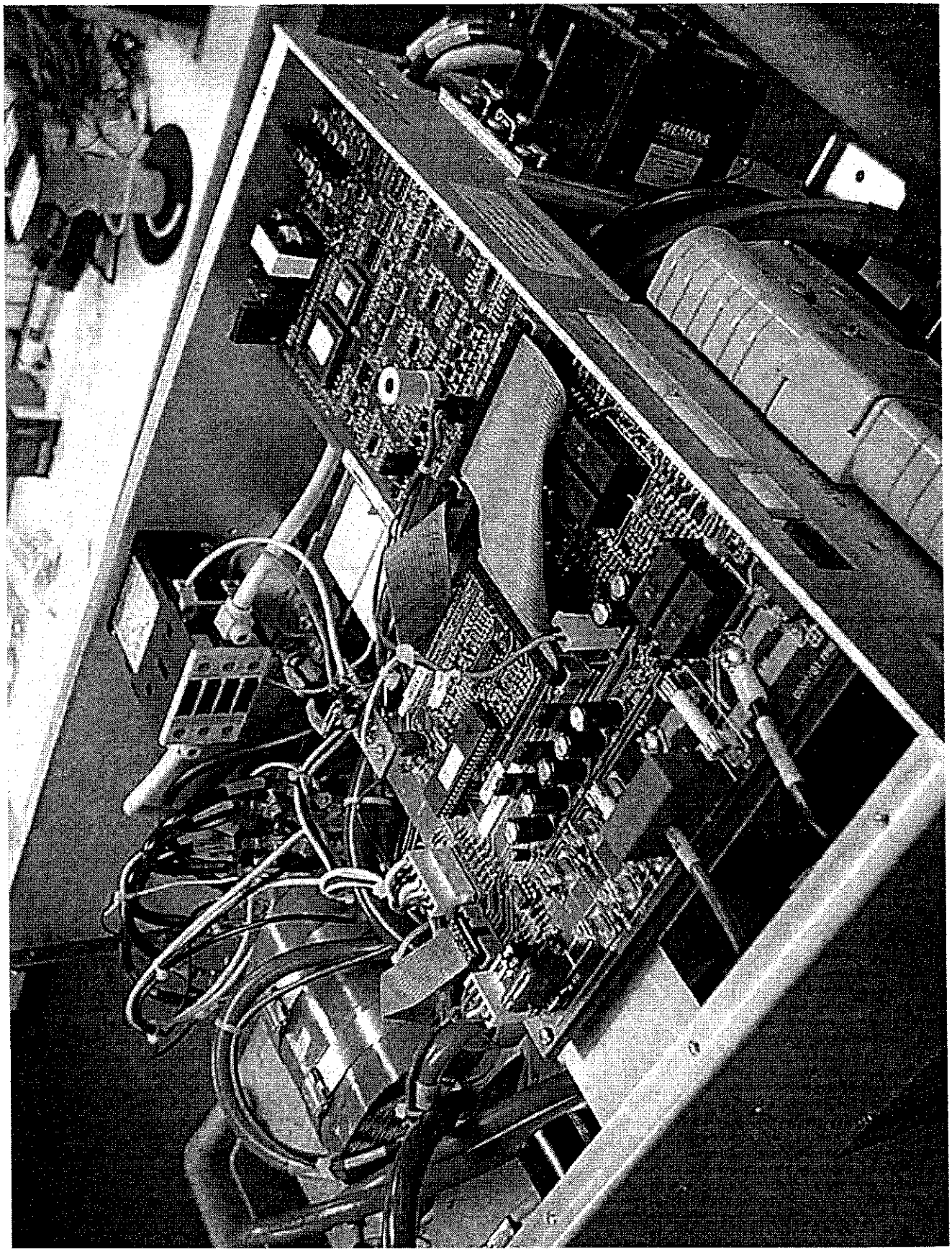
2. Capacitors - Eleven provided, Arcotronics Type MKP-C.4A, rated 60 μF, 250 V ac.

3. PWB - R/C (ZPMV2), 9.5 in by 14.625 in, 4.0 oz copper, rated minimum 105°C.

4. Ribbon Cable - R/C (AVLV2), rated minimum 300 V ac, 105°C. Cable is covered with sleeving/tubing, Item 5, where cables contact uninsulated connectors, wiring and/or bus bars.

5. Sleeving/Tubing - R/C (YDPU2), R/C (YDRY2) or R/C (YDTU2) rated a minimum 300 V ac, 105°C, VW-1.

6. Bus Bar - Located in Inverter circuit 0.25 in. wide by 0.125 in. thick.



N02-00265

TEST RECORD NO. 1

SAMPLES:

Samples as indicated below were submitted by the manufacturer. Each was representative of the construction described in the preceding section of this Report and the following tests were conducted. Test results relate only to the items tested..

Utility Interactive/Multimode, fuel Cell Inverter Model PP-10.

Tests were conducted by the manufacturer at the manufacturer's test facilities located at Wilton, NH and were witnessed by a UL representative.

Tests were considered covered as follows:

Test	File	Report Date	Test Record No.
Temperature in Enclosure, Harmonic Distortion, Input/output Ratings	E206704	11-5-01	1

SINGLE PHASE WAVEFORM TESTING (PER SIR):

GENERAL

Utility interactive inverters shall be non-islanding inverters as defined by IEEE P929. Inverters 10 kW and below shall at the time of production meet or exceed the requirements of IEEE P929 and UL 1741. Specifically,

1. Part A shall investigate the inverter's ability to automatically disconnect for an islanding condition with load quality factor of 2.5 within 2 s.

2. Part B shall investigate the inverter's ability to initiate a trip from a waveform generator for the waveforms described.

METHOD
PART A ANTI-ISLANDING TEST PER IEEE P929

While the inverter was connected to a simulated utility providing output power at nominal voltage and frequency at the point of common coupling (specified below), a parallel RLC resonant circuit was placed between the inverter and simulated utility. The quality factor of the resonant circuit was determined to be 2.5 ± 3 percent (with the exception of operation at 125 percent) and the real load power was to be adjusted to place the inverter at 25, 50, 100 and 125 percent of the inverter's rated output. The reactive load (either capacitive or inductive) was then adjusted to between 95 and 105 percent of the balanced condition in 1 percent steps. At each stop, the inverter's trip time was measured on disconnect from the simulated utility.

PART B WAVEFORM TESTING (PER SIR)

While the inverter was connected to a simulated utility providing output power at nominal voltage and frequency at the point of common coupling (specified below), waveforms as described below were initiated from the simulated utility. The inverter's response to the waveform was recorded and the results were repeated for a total of ten times. A timer was used to determine the time at which the inverter resumed operation following the point of common coupling resuming nominal voltage and frequency. The waveforms are applied line to neutral.

This product measures the line electrical parameters on the utility side of its isolation transformer. Therefore, testing performed at 2 kW is considered representative of the entire product output power range.

Waveform 1 - The inverter was operating within normal utility operating parameters 120 V rms, 60 Hz and the simulated utility voltage was reduced at rate of no greater than 5 Vrms/s, below the 88 percent voltage trip limit, 102 V rms. The inverter must cease to export power within 2 s (120 cycles) of crossing the voltage trip limit. This test shall be repeated ten times.

Waveform 2 - The inverter was operating within normal utility operating parameters 120 V rms, 60 Hz and the simulated utility voltage was increased at rate of no greater than 5 Vrms/s, beyond the 110 percent voltage trip limit, 132 V rms. The inverter must cease to export power within 2 s (120 cycles) of crossing the voltage trip limit. This test shall be repeated ten times.

Waveform 3 - The inverter was operating within normal utility operating parameters 120 V rms, 60 Hz and the simulated utility voltage was quickly increased, beyond the 137 percent voltage trip limit, 162 V rms. The inverter must cease to export power within two cycles of crossing the voltage trip limit. This test shall be repeated ten times.

Waveform 4 - The inverter was operating within normal utility operating parameters 120 V rms, 60 Hz and the simulated utility voltage was quickly decreased, below the 50 percent voltage trip limit, 61 V rms. The inverter must cease to export power within six cycles of crossing the voltage trip limit. This test shall be repeated ten times.

Waveform 6 - the inverter was operating within normal utility operating parameters 120 V rms, 60 Hz and the simulated utility frequency was increased at rate of no greater than 0.5 Hz/s, above the 60.5 Hz frequency trip limit. The inverter must cease to export power within six cycles of crossing the frequency trip limit. This test shall be repeated ten times.

Waveform 7 - The inverter was operating within normal utility operating parameters 120 V rms, 60 Hz and the simulated utility frequency was decreased at rate of no greater than 0.5 Hz/s, below the 59.2 Hz frequency trip limit. The inverter must cease to export power within six cycles of crossing the frequency trip limit. This test shall be repeated ten times.

RESULTS

PART A

Model PP-10.

Rated Output - 240 V ac, 6500 W.

PART B

Simulated Utility Conditions at Point of Common Coupling.

V_{PCC} = 120/240 V ac, $Freq_{PCC}$ = 60 Hz.

Inverter Rated Output = 7.0 kW.

Inverter Output for Test = 2.0 kW.

Waveform 4 - 50 Percent

	Time (Or Cycles) To Disconnect	Reconnection Time
1.	22.4 ms 168 Vp/86 Vp	5 min
2.	22.4 ms	5 min
3.	22.4 ms	5 min
4.	22.4 ms	5 min
5.	22.4 ms	5 min
6.	22.4 ms	5 min
7.	22.4 ms	5 min
8.	22.4 ms	5 min
9.	22.4 ms	5 min
10.	22.4 ms	5 min

Waveform 1 - 88 Percent

	Time (Or Cycles) To Disconnect	Reconnection Time
1.	60.0 ms 168 Vp/144 Vp	5 min
2.	1.10 s	5 min
3.	832 ms	5 min
4.	56.0 ms	5 min
5.	1.18 s	5 min
6.	56.0 ms	5 min
7.	56.0 ms	5 min
8.	56.0 ms	5 min
9.	56.0 ms	5 min
10.	1.15 s	5 min

Waveform 2 - 110 Percent

	Time (Or Cycles) To Disconnect	Reconnection Time
1.	-1.24 s 166 Vp/186 Vp	5 min
2.	-1.18 s	5 min
3.	-1.62 s	5 min
4.	0.336 s	5 min
5.	1.22 s	5 min
6.	0.384 s	5 min
7.	1.14 s	5 min
8.	0.408 s	5 min
9.	0.409 s	5 min
10.	0.264 s	5 min

Waveform 3 - 137 Percent

	Time (Or Cycles) To Disconnect	Reconnection Time
1.	4.2 ms 170 Vp/228 Vp	5 min
2.	4.4 ms	5 min
3.	4.4 ms	5 min
4.	4.4 ms	5 min
5.	4.4 ms	5 min
6.	4.0 ms	5 min
7.	4.0 ms	5 min
8.	4.0 ms	5 min
9.	4.0 ms	5 min
10.	4.0 ms	5 min

Utility Monitoring and Control Circuitry for PP-10, MM3000 and MM5000 Inverters. Tested in Model MM5000.

Waveform 6 Over-Frequency

	Output Power	Trip Frequency	Disconnect Time
1.	1.0 kW	6 c	74.4 ms
2.		60.5 Hz	90.4 ms
3.			90.4 ms
4.			90.4 ms
5.			72.8 ms
6.			72.8 ms
7.			72.8 ms
8.			72.8 ms
9.			89.6 ms
10.			89.6 ms

Waveform 7 Under-Frequency

	Output Power	Trip Frequency	Disconnect Time
1.	1.0 kW	6 c/	73.6 ms
2.		59.2 Hz	89.6 ms
3.			89.6 ms
4.			89.6 ms
5.			89.6 ms
6.			89.6 ms
7.			73.6 ms
8.			90.4 ms
9.			72.8 ms
10.			90.4 ms

In an effort to speed testing, the 5 min reconnect time was shortened to less than 1 min. The 5 min data from the voltage trip limit tests is considered representative of the frequency trip tests.

HARMONIC DISTORTION TEST:

METHOD

Samples of the PP-10 power inverters indicated were subjected to this test. The power inverter was connected to a simulated photovoltaic dc input source of supply. The output was connected to a simulated utility with an impedance of 2 percent of the inverter impedance. The total harmonic current distortion and the maximum single harmonic current distortion were measured.

RESULTS

Model No.	Sample No.	Percent of Output	Phase	Output (A) (V)	Total Harmonic Distortion	Maximum Single Harmonic
PP-10	2	100	L-L	7.1 kW	1.2%	2nd and 3rd 0.4%

The unit did not exceed the 5 percent total current THD.

The unit did not exceed the limit for any individual harmonic as specified by UL 1741.

STATIC INVERTER SURGE TEST (ANSI/IEEE C62.41-1991):

METHOD

The equipment under test (EUT) was connected to a Surge Generator, as defined in ANSI/IEEE C62.41-1991, between the inverter AC output leads and an AC service panel. The service panel was patched at 120/240 V ac, the inverter input was supplied by a lead-acid battery bank.

Ten positive and ten negative surges were applied to the locations as indicated in the following Result Tables. Surge levels and waveforms were defined according to the location categories and system exposure levels as defined in ANSI/IEEE (C62.41-1991 Tables 3, 4 and 5. The Surges were applied to the EUT while it was connected to the Service Panel but not exporting power and while it was connected to the Service Panel and exporting 25 percent power.

At the completion of the surge testing per location the Utility voltage variation test per Section 46.2 of UL 1741 was conducted. The EUT was operating within the normal utility operating parameters and the voltage was decreased at a rate no greater than 5 V rms/s. The EUT must cease to export power within two seconds (120 cycles) after crossing the voltage trip limit of (0.88)(rated voltage) 211 V ac. The EUT was operating within the normal utility operating parameters and the voltage was increased at a rate no greater than 5 V rms/s. The EUT must cease to export power within two seconds (120 cycles) after crossing the voltage trip limit of (1.10)(rated voltage) 264 V ac.

At the completion of surge testing the Dielectric Voltage Withstand Test per section 44.1.1 was conducted. The Dielectric Voltage Withstand was performed at two times the rated output voltage + 1000 V ac between the output leads connected together and the chassis.

Inverter Model: PP-10 Sample No. 1

Inverter Input Power 56 V dc

Output Voltage: 120/240 V ac
Dielectric Test Level: 1480 V ac

Standard 0.5 us-100 kHz Ring Wave
Voltages and Current Surges Expected in Location Categories A and B
Low, Medium, and High Exposures
Single-Phase Modes: L-N, L-G and [L&N]-G
Polyphase Modes: L-L, L-G and [L's]-G

		Peak Values		
Location Category	System Exposure	Voltage (kV)	Current (kA)	Effective Impedance, Ohm
A1	Low	2	0.07	30
A2	Medium	4	0.13	30
A3	High	6	0.2	30
B1	Low	2	0.17	12
B2	Medium	4	0.33	12
B3	High	6	0.5	12

Standard 1.2/50 us-8/20 us Combination Wave
Voltages and Current Surges Expected in Location Categories B and C
Low, Medium, and High Exposures
Single-Phase Modes: L-N, L-G and [L&N]-G
Polyphase Modes: L-L, L-G and [L's]-G

		Peak Values		
Location Category	System Exposure	Voltage (kV)	Current (kA)	Effective Impedance, Ohm
B1	Low	2	1	2
B2	Medium	4	2	2
B3	High	6	3	2
C1	Low	2	3	2
C2	Medium	4	5	2
C3	High	6	10	2

Neutral-Ground Mode Standard Representative Waveforms and Levels
for Maximum Voltage and Current Surges Inside Buildings for
N-G Mode, Depending on Applicable Neutral Earthing
or Bonding Practice

			Applicable Surge			
			0.5 us-100 kHz		1.2/50 us-8/20 us	
Neutral Grounding Practice	Distance From Entrance or Surge Source	System Exposure	Peak Voltage (kV)	Effective Impedance (Ohm)	Peak Voltage (kV)	Effective Impedance (Ohm)
Neutral earthed at service entrance	Close Nearby Far	All All All	None 1 3	None 30 30	None None None	None None None
Neutral not earthed at service entrance	All All All	Low Medium High	2 4 6	12 12 12	2 4 6	2 2 2

RESULTS

100% Power Output

Exposure Category	Wave Type	Voc KV	Isc kA	Surge From	Over/ Under	Dielectric	Results
B3	RW	6.0	0.5	L1-N	OK	-	NC
B3	RW	6.0	0.5	L2-N	OK	-	NC
B3	RW	6.0	0.5	L1-G	OK	-	NC
B3	RW	6.0	0.5	L2-G	OK	-	NC
B3	RW	6.0	0.5	L1-N2	OK	-	NC
B3	CW	6.0	3.0	L1-N	OK	-	NC
B3	CW	6.0	3.0	L2-N	OK	-	NC
B3	CW	6.0	3.0	L1-N	OK	-	NC
B3	CW	6.0	3.0	L2-N	OK	-	NC
B3	CW	6.0	3.0	L1-N	OK	-	NC
B3	CW	6.0	3.0	L,N-G	OK	NB	NC

0% Power Output

Exposure Category	Wave Type	Voc kV	Isc kA	Surge From	Over/ Under	Dielectric	Results
B3	RW	6.0	0.5	L1-N	OK	-	NC
B3	RW	6.0	0.5	L2-N	OK	-	NC
B3	RW	6.0	0.5	L1-G	OK	-	NC
B3	RW	6.0	0.5	L2-G	OK	-	NC
B3	RW	6.0	0.5	L1-L2	OK	-	NC
B3	CW	6.0	0.5	L1-N	OK	-	NC
B3	CW	6.0	0.5	L2-N	OK	-	NC
B3	CW	6.0	0.5	L1-G	OK	-	NC
B3	CW	6.0	0.5	L2-G	OK	-	NC
B3	CW	6.0	0.5	L1-L2	OK	-	NC
B3	CW	6.0	0.5	L,N-G	OK	NB	NC

Codes

Result (per C62.41-1991)

NC - No observed change
UM - Upset, minor
UX - Upset, major
UC - Upset, critical
DG - Damage
CD - Consequential damage

Surge

LL - Line-to-line
LN - Line-to-neutral
LG - Line-to-ground
NG - Neutral-to-ground
LNG - Line and neutral-to-ground
R - Reverse polarity (used with above)
RW - Ring Wave
CW - Combination Wave

Dielectric Withstand

NB - No breakdown
DB - Dielectric breakdown
FO - Momentary flashover

TEMPERATURE TEST AT RAISED AMBIENT:
With Module In Plug Power Enclosure

METHOD

A sample of the ac module power inverter indicated below was subjected to this test. The sample was connected to its rated dc source. The output was connected to its rated utility supply and a solid state load in parallel and adjusted to obtain the rated output current.

Each unit was operated under these conditions until temperatures became constant for the time increment indicated. Each test was conducted with the sample starting at ambient temperature.

Temperatures were measured by thermocouples.

Test	Model	Sample No.	Input, V dc	I dc	Output			Test Duration	pF
					V ac	I ac	kVA		
B	SU1PCM-059622	1	70	124	120	27.2	6.5	6.5 h	1.0
					120	27.0			

Location of Thermocouples	Maximum Temperature, °C
	Test B
Ambient	37
Large transformer coil	77
Large inductor core	103
Large inductor coil	106
Charge inductor coil	89
Electrolytic cap	52
Semikron pressure plate	77
Heat sink	59
New toroid inductor coil	47
New toroid inductor core	47
Center battery side	56
Enclosure outside rear	58
Enclosure top	40
Internal ambient	48
Battery link	61
Ambient above inverter cabinet (open)	40

DIELECTRIC VOLTAGE WITHSTAND TEST:

METHOD

Immediately after the temperature test, each sample was subjected to a 60 Hz ac or dc potential, as indicated below, for 1 min in each test:

AC and DC Power Circuits

A. 1480 V ac between AC output circuit and dead-metal parts with grounding connection, if provided, disconnected,

B. 1480 v ac between AC input and DC input, primary and secondary windings, of isolating transformer.

RESULTS

The spacings and insulation withstood the application of the specified potential for 1 min without breakdown.

OUTPUT SHORT CIRCUIT ABNORMAL TESTS:

METHOD

Samples of the power inverters indicated below were subjected tot his test. The input circuits were connected to a simulated fuel cell and a battery pack source of supply. The output circuits were connected to No. 6 AWG output leads 10 ft in total length which resulted in a short circuit condition. The short was applied between 1 phase and neutral and phase to phase.

The source of supply was fused in accordance to manufacturer's installation instructions.

The test was continued for 3 c of operation since a manual reset protector is employed in the secondary output circuit> (47.1.7, Exception No. 1, 3 c.)

Line Voltage - 120/240

DC Input - Fuel Cell 60 V dc, 125 A, battery pack was charging.

The inverter was run at approx 1/2 of its rated output power, 5.0 kW load. The DC input was grounded on the negative side.

RESULTS

Model	Sample No.	Type of Unit Protection Provided	Test Condition (Charger/ Inverter)	Did External 3 A Ground Fuse in Input Circuit Open?	Remarks
PP-10	1	100 A, C, B	Phase-Phase	No	(+) (++)
PP-11	1	100A, C, B	Neutral-Phase	No	(+) (++)

(+) Unit shut down; AC-CB did not trip, unit auto restarts after fault removed. Needed clamping circuit to protect the FETs hardware.

(++) Unit still shut down with electrolytic caps disconnected, auto restarts when fault removed.

There was no emission of flame or molten metal.

Unit shut down; AC circuit breaker did not open; unit would not restart; error message, trouble signal on Semikron modules.

Dielectric DC-DC; AC-Gnd; DC-GND, 1480 V ac.

REVERSE DC INPUT TEST:

METHOD

An as-received sample of the photovoltaic utility interactive static inverter, Model PP-10 was subjected to this test. The fuel cell was connected and operating at 65 V dc. The AC output was connected in its rated input. The inverter was connected to the battery pack, through a Buss fuse, Type ANN-350, rated 350 A, opposite to the intended connection, positive to negative and negative to positive. The test was run for 7 h or until ultimate results. Unless otherwise indicated, immediately following completion of the test a dielectric potential of twice rated voltage plus 1000 V was applied as follows for a period of 1 min during each test:

A. 1480 V ac between DC input, AC output circuit and dead-metal parts.

B. 1480 V ac between DC input, and AC output and secondary control circuits.

The battery pack was fully charged, rated 48.0 V dc (open circuit 51.5 V dc).

RESULTS

The unit did not ignite or char cheesecloth, the 3 A ground fuse did remain intact. There was no dielectric breakdown. The unit functioned normally after the fault condition was removed.

COMPONENT MALFUNCTION ABNORMAL TEST:

METHOD

A sample of each model tabulated under Results was subjected to this test. Various components were short circuited or open circuited as indicated below. Tests which resulted in the opening of components or component damage were followed by a dielectric withstand test as described in the following pages.

The battery pack was fused with a 350 A fuse Buss fuse Type ANN-350, the fuel cell was protected with a 300 A circuit breaker.

RESULTS

Model	Input, V dc	Component Designation	Test Condition	Observations	Withstand Dielectric (Yes/No)	3 A Ground Fuse (Yes/No)
PP-10	A	C1	Short	(+)	OK	Ok
	A	U20	Open	(++)	OK	OK
	A	X1	Open	(++)	OK	OK
	A	U2	Short	(+++)	OK	OK
	A	Output of T1	Opened	(+++)	OK	OK
	A	B	Short	(+++)	OK	OK

A 48 V dc from battery pack and 70 V dc from fuel cell.
U20 Crystal for main CPU.
X1 Crystal for I/O CPU.
B Capacitor on inverter/charger PCB.
(+) Trace on PCB opened.
(++) Unit shut down.
(+++) Unit did not function after fault was removed.

There was no emission of flame or molten metal. There was no dielectric breakdown.

LOSS OF CONTROL CIRCUIT TEST:

METHOD

The unit was connected to a simulated fuel cell and a battery pack. The output was monitored by a storage oscilloscope under the following fault conditions and operated at approx 50 percent of rated power.

RESULTS

Model	Component	Short/Open
PP-10	T1	Open

The unit did cease output power during the control circuit faults.

The unit did withstand the dielectric test.

NEUTRAL CONTACTOR TEST:

METHOD

During guide export the inverter opens the neutral contactor. The interactive inverter was connected to the simulated grid, exporting power. The neutral contactor was open. The inverter output was changed from grid connect to stand alone. The test was repeated three times output.

RESULTS

The neutral contactor did close properly.

CONCLUSION

Samples of the products covered by this Report have been found to comply with the requirements covering the category and the products are judged to be eligible for Listing and Follow-Up Service. The manufacturer is authorized to use the UL Mark on such products which comply with the Follow-Up Service Procedure and any other applicable requirements of Underwriters Laboratories Inc. Only those products which properly bear the UL Mark are considered as Listed by Underwriters Laboratories Inc.

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SUFFIX NOMENCLATURE:

For details see the individual sections.

(+) - Any number 0 through 9.
(#) - Any letter A through Z.
(*) - Any letter A through Z or any number 0 through 9.